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Title of the Invention

Multilayer Wiring Board

#### Abstract

**Problem:** Air is present between organic resin insulating layers positioned in the vertical direction, thereby deteriorating bonding strength.

**Solution:** A multilayer wiring board comprising: a substrate 1; organic resin insulating layers 2 and thin-film wiring conductor layers 3 which are alternately laminated on the substrate 1; a plated-through hole 8 provided in each of the organic resin insulating layers 2; and a plated-through hole conductor 9, attached to an inner wall of the plated-through hole 8, for connecting the thin-film wiring conductor layers 3 positioned so as to interpose the organic resin insulating layer 2 therebetween to each other, wherein the thin-film wiring conductor layer 3 placed between the organic resin insulating layers 2 has a thickness of 3  $\mu\text{m}$  to 10  $\mu\text{m}$ .

#### Claim

1. A multilayer wiring board comprising:  
a substrate;  
organic resin insulating layers and thin-film wiring conductor layers which are alternately laminated on the substrate;  
a plated-through hole provided in each of the organic resin insulating layers; and

a plated-through hole conductor, attached to an inner wall of the plated-through hole, for connecting the thin-film wiring conductor layers positioned so as to interpose the organic resin insulating layer therebetween to each other, wherein

the thin-film wiring conductor layer placed between the organic resin insulating layers has a thickness of 3  $\mu\text{m}$  to 10  $\mu\text{m}$ .

#### Detailed Description of the Invention

[0001]

#### Technical Field Pertinent to the Invention

The present invention relates to a multilayer wiring board, and more particularly to a multilayer wiring board used for a semiconductor element housing package or the like of a hybrid integrated circuit device and a semiconductor element.

[0002]

#### Prior Art

Conventionally, with respect to a multilayer wiring board used for a package or the like for housing a hybrid integrated circuit device and a semiconductor element, the wiring conductor is formed by a thick film formation technique such as a Mo-Mn method or the like.

[0003]

The Mo-Mn method is generally a method involving adding and mixing an organic solvent or solute to and with a high melting point metal powder of tungsten, molybdenum, manganese or the like to obtain a metal paste in paste state, printing and applying the metal paste in a prescribed

pattern on the outer surface of a green body by a screen printing method, and then laminating a plurality of such green bodies and firing the green bodies in reducing atmosphere to sinter and integrate the high melting point metal powder and the green bodies.

[0004]

Herein, as the above-mentioned ceramic body on which the wiring conductor is formed, generally, an oxide-based ceramic such as an aluminum oxide-type sintered body, a mullite type sintered body, or a non-oxide-based ceramic an aluminum nitride type sintered body, a silicon carbide type sintered body or the like bearing an oxide film on the surface can be used.

[0005]

However, in the case where a wiring conductor is formed by employing the Mo-Mn method, since the wiring conductor is formed by screen-printing a metal paste, there is a disadvantage that the wiring conductor is difficult to be made fine and highly dense.

[0006]

In order to solve the above-mentioned disadvantage, the present inventors proposed before a multilayer wiring board with a high density in JP Shutsugan Hei 8-94433 by employing a thin film formation technique capable of making fine wiring possible in place of a conventional thick film formation technique to form a wiring conductor.

[0007]

Such a multilayer wiring board has a structure formed by alternately laminating organic resin insulating layers of an epoxy resin with a thickness of 5  $\mu\text{m}$  to 100  $\mu\text{m}$  formed by a spin coating method and

thermally curing treatment and thin-film wiring conductor layers of a metal such as copper, aluminum or the like with a thickness of 1  $\mu\text{m}$  to 40  $\mu\text{m}$  formed by employing a thin film formation technique and a photolithographic technique such as a plating method, an evaporation method or the like in multilayers on an upper face of an insulating substrate of a ceramic such as an aluminum oxide type sintered body and the like and a glass epoxy resin obtained by impregnating glass cloth of woven or glass fibers with an epoxy resin and then electrically connecting the thin-film wiring conductor layers positioned so as to interpose a plated-through hole conductor deposited on the inner wall of a plated-through hole formed in an organic resin insulating layer therebetween.

[0008]

With respect to the multilayer wiring board, plated-through holes formed in the respective organic resin insulating layers are formed by employing a photolithographic technique, particularly, by at first applying a resist layer on an organic resin insulating layer, exposing and developing the resist layer to form a window part with a prescribed shape at a prescribed position, and then treating the window part of the resist layer with an etching solution to remove an organic resin insulating layer positioned in the window part of the resist material to form a hole (through hole) in the organic resin insulating layer, and finally removing the resulting resist material from the organic resin insulating layer.

[0009]

Problems to be Solved by the Invention

The above-mentioned multilayer wiring board is adjusted to have a

thickness of the thin-film wiring conductor layers in a range 1  $\mu\text{m}$  to 40  $\mu\text{m}$  in order to lower the electric resistance value of the thin-film wiring conductor layers to well transmit electric signals to the thin-film wiring conductor layers and at the same time to lower the stress generated at the time of forming the thin-film wiring conductor layers to make the junction between each organic resin insulating layer and thin-film wiring conductor layer.

[0010]

However, if it is tried to make the thickness of each thin-film wiring conductor layer less than 3  $\mu\text{m}$ , the thickness of the thin-film wiring conductor layer is considerably affected by the surface condition of the upper face of an organic resin insulating layer thereunder and becomes considerably uneven and, consequently, it is made difficult to control the electric resistance value of the thin-film wiring conductor layers to be a desired value, whereas if it exceeds 10  $\mu\text{m}$ , at the time when a next organic resin insulating layer is laminated on an organic resin insulating layer bearing a thin-film wiring conductor layer with a thickness exceeding 10  $\mu\text{m}$  thereon, air existing in the side face parts of the thin-film wiring conductor layer is entrained in the organic resin insulating layer to be formed thereon and, consequently, the bonding strength between organic resin insulating layers positioned in the vertical direction is decreased to result in deterioration of the reliability as the multilayer wiring board, which is a problem to be solved.

[0011]

The present invention is proposed taking the above-mentioned

disadvantages into consideration, and an object thereof is to provide a multilayer wiring board comprising a desired electric resistance value of thin-film wiring conductor layers and having a high bonding strength between organic resin insulating layers positioned in the vertical direction and high reliability.

[0012]

#### Means for Solving the Problems

A multilayer wiring board according to the present invention comprises: a substrate; organic resin insulating layers and thin-film wiring conductor layers which are alternately laminated on the substrate; a plated-through hole provided in each of the organic resin insulating layers; and a plated-through hole conductor, attached to an inner wall of the plated-through hole, for connecting the thin-film wiring conductor layers positioned so as to interpose the organic resin insulating layer therebetween to each other, wherein the thin-film wiring conductor layer placed between the organic resin insulating layers has a thickness of 3  $\mu\text{m}$  to 10  $\mu\text{m}$ .

[0013]

According to the multilayer wiring board of the present invention, since the wiring is formed on a substrate by a thin film formation technique, it is made possible to make the wiring fine and highly dense.

[0014]

Further, according to the multilayer wiring board, since the thickness of the thin-film wiring conductor layer is set to be 3  $\mu\text{m}$  to 10  $\mu\text{m}$ , the thin-film wiring conductor layers are made almost even without being affected by the upper face condition of the organic resin insulating layer

thereunder and, accordingly, the electric resistance value of the thin-film wiring conductor layers can be adjusted to be a prescribed value and at the same time, when a next organic resin insulating layer is laminated on an organic resin insulating layer bearing a thin-film wiring conductor layer, a large quantity of air existing in the side face parts of a thin-film wiring conductor layer is scarcely entrained in an organic resin insulating layer to be formed thereon and thus bonding strength between the organic resin insulating layers in the vertical direction is scarcely decreased and, consequently, the reliability as a multilayer wiring board is made high.

[0015]

#### Embodiments of the Invention

Next, the present invention will be described in details on the basis of attached drawings. Fig. 1 shows an embodiment of a multilayer wiring board of the present invention and the reference numeral 1 denotes an insulating substrate, 2 denotes organic resin insulating layers and 3 denotes thin-film wiring conductor layers.

[0016]

The above-mentioned substrate 1 bears a multilayer wiring part 4 composed of organic resin insulating layers 2 and thin-film wiring conductor layers 3 on the upper face and functions as a supporting member of the multilayer wiring part 4.

[0017]

The above-mentioned substrate 1 is made of an electrically insulating material such as an oxide-based ceramic such as an aluminum oxide type sintered body, a mullite type sintered body, a non-oxide-based

ceramic such as an aluminum nitride sintered body, a silicon carbide sintered body bearing an oxide film on the surface, or a glass epoxy resin obtained by impregnating glass cloth of woven glass fibers with an epoxy resin and in the case where it is made of, for example, an aluminum oxide sintered body, the substrate is produced by producing a slurry by adding a proper organic solvent or solute to a raw material powder of such as alumina, silica, calcia, magnesia and the like, producing ceramic green sheets (ceramic raw sheets) from the slurry by employing a conventionally known doctor blade method, a calender roll method, and then subjecting the green sheets to proper punching process to form them in proper shapes, firing the resulting green sheets at a high temperature (about 1600°C) or by preparing a raw material powder slurry by adding a proper organic solvent or solute to a raw material powder of such as alumina, forming the prepared raw material powder into a prescribed shape by a press forming apparatus, and finally firing the resulting green sheets at a temperature of about 1600°C and in the case the substrate is made of glass epoxy resin, for example, it is produced by impregnating a woven cloth of glass fibers with a precursor of an epoxy resin and thermally curing the epoxy resin precursor at a prescribed temperature.

[0018]

Also, in the above-mentioned substrate 1, through holes 5 with a diameter of, for example, 0.3 mm to 0.5 mm penetrating both upper and lower faces are formed and conductor layers 6 led out to both upper and lower faces of the substrate 1 are formed in both ends of the inner walls of the through holes 5.



[0019]

The above-mentioned through holes 5 electrically connect thin-film wiring conductor layers 3 of a multilayer wiring part 4 formed on the upper face 1 as it will be described later with an external electric circuit. Or, in the case of multilayer wiring parts 4 are formed in both upper and lower faces of the substrate 1, the through holes work as formation holes for forming conductor layers 6 for electrically connecting the thin-film wiring conductor layers 3 in both faces of the multilayer wiring part 4.

[0020]

Further, the conductor layers 6 are deposited in the inner walls of the above-mentioned through holes 5 and both of the upper and lower faces of the substrate 1 and the above-mentioned conductor layers 6 are made of a metal material such as copper, nickel and the like and formed in the inner walls of the through holes 5 and both of the upper and lower faces of the substrate 1 while the both ends being led out to both upper and lower faces of the substrate 1 by employing a conventionally known plating method and etching processing technique.

[0021]

The above-mentioned conductor layers 6 electrically connect thin-film wiring conductor layers 3 of a multilayer wiring part 4 formed on the upper face 1 with an external electric circuit, or the conductor layers electrically connect the thin-film wiring conductor layers 3 of both multilayer wiring parts 4 formed in both upper and lower faces of the substrate 1.

[0022]

Further, the insides of the through holes 5 formed in the above-mentioned substrate 1 are filled with an organic resin filler 7 of an epoxy resin and the through holes 5 are completely filled with the above-mentioned organic resin filler 7 and at the same time, both end faces of the organic resin filler 7 are in the same plane of the faces of the conductor layers 6 formed in both upper and lower face of the substrate 1.

[0023]

The above-mentioned organic resin filler 7 has a function of keeping the flatness of organic resin insulating layers 2 and thin-film wiring conductor layers 3 of a multilayer wiring part 4 in the case where the multilayer wiring part 4 comprising the organic resin insulating layers 2 and the thin-film wiring conductor layers 3 is formed on the upper face and/or the lower face of the substrate, which will be described later.

[0024]

The above-mentioned organic resin filler 7 is filled in the through holes 5 of the substrate 1 by filling the inside of the through holes 5 with a precursor of an epoxy resin and then completely thermally curing the precursor by heating at 80 to 200°C for 0.5 to 3 hours.

[0025]

Further, the above-mentioned substrate 1 bears the multilayer wiring part 4 on the upper face formed of alternately laminated the organic resin insulating layers 2 and the thin-film wiring conductor layers 3 in multilayers and some of the thin-film wiring conductor layers 3 are electrically connected with a conductor layer 6.

[0026]

Each of the organic resin insulating layers 2 constituting the above-mentioned multilayer wiring part 4 electrically insulates the thin-film wiring conductor layers 3 positioned so as to be interposed between the multilayer wiring parts 4 and the thin-film wiring conductor layers 3 function as transmission paths for transmitting electric signals.

[0027]

The organic resin insulating layers 2 of the above-mentioned multilayer wiring part 4 are made of an epoxy resin by, for example, producing a paste-state epoxy resin precursor by adding and mixing a curing agent such as an amine-based curing agent, an imidazole-based curing agent, or an acid anhydride-based curing agent to and with a bisphenol A type epoxy resin, a novolak type epoxy resin, or a glycidyl ester type epoxy resin, applying the above-mentioned epoxy resin precursor on the upper part of a substrate 1 by a spin coating method, and then thermally curing the epoxy resin by heating at about 80 to 200°C for 0.5 to 3 hours.

[0028]

Also, in the organic resin insulating layers 2, plated-through holes 8 with the minimum diameter of about 1.5 times as wide as the thickness of each organic resin insulating layer 2 are formed at respectively prescribed positions and the plated-through holes 8 are utilized for forming plated-through hole conductors 9, which will be described later, to electrically connect the respective thin-film wiring conductor layers positioned so as to interpose each organic resin insulating layer 2.

[0029]

The plated-through holes 8 in the above-mentioned organic resin insulating layers 2 are formed by a photolithographic technique, practically by applying a resist layer on an organic resin insulating layer 2, exposing and developing the resist layer to form a window part with a prescribed shape at a prescribed position, and then treating the window part of the resist layer with an etching solution to remove an organic resin insulating layer positioned in the window part of the resist material to form a hole (through hole) in the organic resin insulating layer, and finally removing the resulting resist material from the organic resin insulating layer.

[0030]

Further, a thin-film wiring conductor layer 3 of a prescribed pattern is formed on the upper face of each of the above-mentioned organic resin insulating layers 2 and a plated-through hole conductor 9 is respectively attached to the inner walls of the plated-through holes 8 formed in the respective organic resin insulating layers 2 and the plated-through hole conductor 9 electrically connects respective thin-film wiring conductor layers 3 positioned so as to interpose the organic resin insulating layer 2.

[0031]

The thin-film wiring conductor layers 3 formed on the upper face of the respective organic resin insulating layers 2 and the plated-through hole conductor 9 disposed in the plated-through holes 8 are formed by employing a thin film formation technique and an etching processing technique such as an electroless plating method, an evaporation method, a sputtering method and the like of a metal material such as copper, nickel, gold, aluminum and the like and in the case of, for example, formation using copper, a copper

layer with a thickness of 1  $\mu\text{m}$  to 40  $\mu\text{m}$  is deposited on the upper face of an organic resin insulating layer 2 and the inner wall faces of plated-through holes 8 in an electroless copper plating bath containing 0.06 mole/L of copper sulfate, 0.3 mole/L of formalin, 0.35 mole/L of sodium hydroxide, and 0.35 mole/L of ethylenediamine tetraacetate, and then processing the above-mentioned copper layer in a prescribed pattern by employing an etching processing technique to form the thin-film wiring conductor layers between respective organic resin insulating layers 2 and inner walls of the plated-through holes 8 of the respective organic resin insulating layers 2. In this case, the thin-film wiring conductor layers 3 can be formed by a thin film formation technique, so that it is made possible to form fine wiring and accordingly the thin-film wiring conductor layers 3 can be formed at an extremely high density.

[0032]

If the thickness of the respective organic resin insulating layers 2 of the above-mentioned multilayer wiring part 4 exceeds 100  $\mu\text{m}$ , in the case of formation of the plated-through holes 8 in the respective organic resin insulating layers 2 by employing a photolithographic technique, it becomes difficult to form the plated-through holes 8 with a desired clear shape owing to prolongation of the processing duration of the etching and if it is thinner than 5  $\mu\text{m}$ , at the time when surface roughening process is carried out for the upper face of an organic resin insulating layer 2 in order to improve the bonding strength between thin-film wiring conductor layers 3 in the upper- and under-levels, there is a risk that unnecessary holes are formed in the organic resin insulating layer 2 to result in unnecessary short circuit

between the thin-film wiring conductor layers 3 positioned in the upper- and under-levels. Accordingly, the thickness of each above-mentioned organic resin insulating layer 2 is preferably in a range of 5  $\mu\text{m}$  to 100  $\mu\text{m}$ .

[0033]

On the other hand, if the thickness of each thin-film wiring conductor layer 3 of the above-mentioned multilayer wiring part 4 is thinner than 3  $\mu\text{m}$ , the thickness of the thin-film wiring conductor layer 3 differs significantly with a wide dispersion because of the effect of the surface state of the upper face of an organic resin insulating layer 2 thereunder and consequently, it becomes difficult to adjust the electric resistance values of thin-film wiring conductor layers 3 to be a desired value, whereas it exceeds 10  $\mu\text{m}$ , at the time when the an organic resin insulating layer 2 is laminated on another organic resin insulating layer 2 bearing a thin-film wiring conductor layer 3 on the upper face, a large quantity of air existing in the side face parts of the thin-film wiring conductor layer 3 is entrained in the organic resin insulating layer to be formed thereon and thus bonding strength between the organic resin insulating layers in the vertical direction is decreased and consequently, the reliability as a multilayer wiring board is deteriorated. Accordingly, the respective thin-film wiring conductor layers 3 of the above-mentioned multilayer wiring part 4 are required to have a thickness in a range of 3  $\mu\text{m}$  to 10  $\mu\text{m}$  in order to well transmit electric signals to through the thin-film wiring conductor layers 3, to make the bonding strength between organic resin insulating layers in the vertical direction, and to give high reliability of the multilayer wiring board.

[0034]

Herein, with respect to the multilayer wiring part 4 formed by alternately forming the above-mentioned organic resin insulating layers 2 and thin-film wiring conductor layers 3 in multilayers, the through holes 5 formed in the substrate 1 are completely filled with an organic resin filler 7, so that even if an organic resin insulating layer 2 is formed on the upper face of the substrate 1, the organic resin insulating layer 2 is kept to be flat and thus occurrence of disconnection by a thin-film wiring conductor layer 3 can be efficiently prevented.

[0035]

Consequently, according to a multilayer wiring board of the present invention, by mounting positive components such as semiconductor elements and passive components such as capacitor elements, resistors and the like on the multilayer wiring part 4 deposited on the upper face of the substrate 1, the resulting multilayer wiring board becomes a semiconductor device and a hybrid integrated circuit apparatus and by connecting the conductor layer 6 deposited in the lower face of the substrate 1 to an external electric circuit, the semiconductor device and the hybrid integrated circuit apparatus are electrically connected to the external electric circuit.

[0036]

Herein, the present invention is not limited to the above-mentioned embodiment and any modifications can be made within a true scope of the present invention and for example, in the above-mentioned embodiment, the multilayer wiring part 4 comprising the organic resin insulating layers 2 and the thin-film wiring conductor layers 3 is formed only on the upper face of the substrate 1, the multilayer wiring part 4 may be formed only on the

lower face or on both upper and lower faces of the substrate 1.

[0037]

#### Effects of the Invention

According to a multilayer wiring board of the present invention, wiring is formed by a thin film formation technique on a substrate, it is made possible to make the wiring fine and highly dense.

[0038]

Further, according to a multilayer wiring board of the present invention, the thickness of the respective thin-film wiring conductor layers is adjusted to be 3  $\mu\text{m}$  to 10  $\mu\text{m}$ , so that a thin-film wiring conductor layer can be made approximately even without being not so much affected by the surface state of the upper face of an organic resin insulating layer thereunder and accordingly, the electric resistance value of the thin-film wiring conductor layer can be adjusted to be a prescribed value and at the same time, when a next organic resin insulating layer is laminated on an organic resin insulating layer bearing a thin-film wiring conductor layer, a large quantity of air existing in the side face parts of the thin-film wiring conductor layer is scarcely entrained in the organic resin insulating layer to be formed thereon and thus bonding strength between the organic resin insulating layers in the vertical direction is scarcely decreased and consequently, the reliability as a multilayer wiring board is made high.

#### Brief Description of the Drawings

Fig. 1 is a cross-sectional view showing an embodiment of a multilayer wiring board of the present invention.

#### Explanation of Symbols



- 1: substrate
- 2: organic resin insulating layer
- 3: thin-film wiring conductor layer
- 4: multilayer wiring part
- 8: plated-through hole
- 9: plated-through hole conductor